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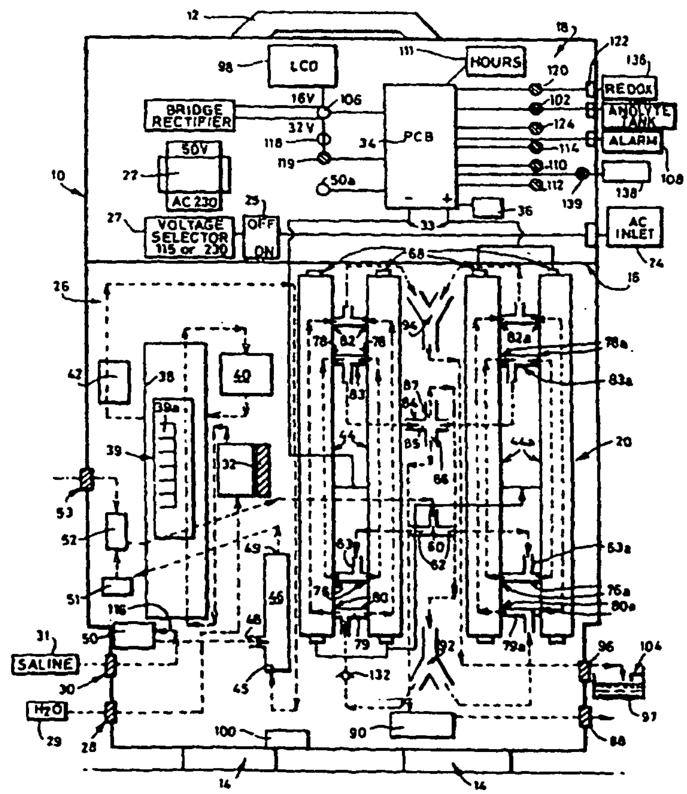
(57) Abstract

A method of electroprocessing liquid such as water comprises providing an electrolyser with cathode and anode chambers, each having respective electrodes. An electric current source is provided for the electrodes. Liquid is passed through an inlet of the cathode chamber (76) and passes from the cathode chamber at least partly to an inlet of the anode chamber (80) with the remainder passing along a further flow path to an outlet (88). Apparatus is provided for carrying out the method including a hydraulic valving arrangement to allow control of flow of liquid from cathode to anode and along the further flow path.



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ELECTROCHEMICAL PROCESSING OF LIQUID SUCH AS WATER

The invention relates to apparatus for and a method of electrochemical processing of liquids such as water. In particular, but not exclusively, the invention is concerned with the processing of water by electrochemical treatment for producing potable water or, for example, a disinfection, sterilising or washing/extraction solutions.

In US Patent No. 5635040 an electrolyser is described and the contents of the foregoing specification are herein incorporated by reference. In US Patent No. 5635040, the electrolysing device comprises two vertical coaxial electrodes in the form of a cylinder and a coaxial rod between which is interposed an ultra-filtering diaphragm. An anode chamber is defined between one of the electrodes and the diaphragm and a cathode chamber is defined between the other of the electrodes and the diaphragm. In use, an electrolyte passes through the electrolyser and electric current is applied to the electrodes. The required treated water emerges as an anolyte from the anode chamber or catholyte from the cathode chamber.

One object of the present invention is to provide apparatus for electrochemical processing of liquid which can use an electrolyser of the type shown in US Patent No. 5635040.

According to a first aspect of the invention there is provided a method of electrochemical processing liquid such as water comprising providing an electrolyser having cathode and anode chambers, the chambers including respective electrodes providing an electric current source for the electrodes of the electrode chambers, supplying to the electrolyser liquid to be subjected to the electrochemical processing and causing liquid from the cathode chamber to flow at least partly to the anode, the remainder flowing along a further flow path.

According to a second aspect of the invention there is provided apparatus for electro processing liquid such as water comprising an electrolyser having cathode and anode chambers, means for providing an electric current source for the electrodes of the chambers, and means for causing liquid from the cathode to flow at least partly to the anode, the remainder flowing along a further flow path.

The further flow path may include flow control means, such as a flow adjuster, for controlling flow along the further path.

The aforesaid means for causing flow of liquid at least partly from the cathode to the anode and partly along the further flow path may comprise a device having a substantially unrestricted inlet for the liquid from said

cathode and first and second outlets one of which may provide a greater resistance to flow therethrough than the other.

Means may be provided for sensing the pH value of a solution being treated by the processed liquid so that if the pH value changes from a predetermined value, control means such as the aforesaid flow control means may be adjusted to control the rate of liquid flow along the further path which preferably alters the flow rate of liquid from the cathode chamber to the anode chamber of the electrolyser. The means for sensing the pH value may also be used for determining the pH of the processed liquid and controlling the pH by using the aforesaid flow control means.

Means may also be provided for sensing Redox or oxidant value of the solution being treated by the processed liquid whereby if the value varies from a predetermined value, the processing of the liquid is stopped to maintain the value of the treated liquid and then started again when required.

Electrolyte, for example in the form of a saline solution, may be drawn from a supply by supply means such as a peristaltic pump.

The electrolyte may be fed by the supply means to a mixing device such as an T-junction which receives the liquid to be processed so that the saline solution and liquid to be processed can be mixed together.

Where the apparatus is used for electro-processing water having a significant calcium and/or magnesium content, it is desirable to clean the apparatus to remove calcium deposits which can interfere with liquid flow through the apparatus. Means may be provided for indicating the need to clean the apparatus when resistance to flow increases as a result of the build up of lime scale. In order to clean the apparatus, means maybe provided for introducing a cleaning solution into the apparatus so that the cleaning solution flows through a selected part of the apparatus preferably downstream of the mixing device. In that respect, valve means may be provided for introducing cleaning solution from a suitable source. After cleaning is complete, the method in accordance with the invention preferably includes the step of flushing with liquid such as clean water, those parts of the apparatus which have been cleaned by the cleaning solution.

In order to minimise back pressure through the electrolyser, liquid which flows through the aforesaid further flow path may be drawn along the path by a suitable suction device such as a vortex. In such a case, a non-

return valve may be provided in the flow path for the liquid which flows partly to the other chamber of the electrolyser to prevent the suction means from drawing liquid through the electrolyser in a reverse direction.

In a preferred embodiment, two pairs of electrolysers are provided which may be electrically connected in series or parallel. The two pairs of electrolysers are connected so that the anode chambers are connected together in parallel and the cathode chambers are connected together in parallel. It will be appreciated that any convenient number of electrolysers may suitably be connected together.

Preferably, the electrolyser or each of the electrolysers may be an elongate tubular electrolyser preferably of the type disclosed in US Patent No. 5635040 and may extend vertically. In such a case. inlet means to the electrode chambers may be arranged at the lower end of the or each electrolyser and outlet means from the electrode chambers at the upper end.

Preferably, the apparatus is portable for providing, for example, on-the-spot purification of water.

The housing may be divided into upper and lower sections. The upper

section may include the aforesaid means for providing the electric current source with the lower section containing the electrolyser and components associated with the liquid flow. The housing may be provided with suitable inlets for the liquid and an electrolyte and suitable respective outlets for the required processed liquid and by-product from the electrolyser.

An apparatus and method in accordance with the invention will now be described by way of example with reference to the accompanying drawings in which:-

Fig 1 is a diagrammatic elevation of one form of apparatus in accordance with the invention,

Fig 2 is a diagrammatic cross-section through an electrolyser suitable for use in the apparatus shown in Fig 1 and

Fig 3 is a flow diagram showing a control sequence of the apparatus.

With reference to Fig 1, housing 10 may be provided with a carrying handle 12 and ground engageable feet 14. The housing may be of a rectangular/cuboid type or other suitable shape. If desired, the housing

10 may be provided with ground engageable wheels or castors.

The housing 10 is provided with a horizontal divider 16 which divides the housing into upper and lower sections 18, 20. The upper section 18 contains a transformer 22 which receives power from an external AC source 24 such as mains electricity via an on-off switch 25. The lower section 20 contains liquid ducting and processing components of the apparatus indicated generally at 26. Although liquid flow paths are shown, interconnecting conduit has been omitted. A voltage selector 27 is provided for mains voltages of, say 115v or 230 v.

Looking at the lower section 20, the housing 10 carries a coupling 28 for water from an external source, e.g. from a suitable mains 29, and a further coupling 30 which, in use, is connected to a suitable electrolyte source 31 such as a saline solution. Water from source 29 then flows in the direction of the arrows to a solenoid valve 32 which receives electric current from a controller 34 in the upper section 18 of the housing, the controller 34 being arranged to receive power from the transformer 22. The controller 34 includes a printed circuit board carrying electronic components. An electrical switch 36 such as a press start switch is provided on the housing 10 for operating the solenoid valve 32. The solenoid valve 32 is normally closed when the power is

switched off.

When the valve 32 is opened by operating switch 36, water is permitted to flow to a flow gauge 38 of known kind (for example available from CT Platon of Basingstoke England). A suitable flow gauge is the Model GI. From the flow gauge 38, water flows to a flow regulator comprising a flow-stat 40 of known kind available from CT Platon of Basingstoke. A suitable flow-stat is the Model MN. The flow gauge 38 is calibrated, for example to allow water to flow therethrough at 0.2 - 1.5 litres per minute. The system shown in Fig 1 is preferably set to indicate a flow requirement of 1 to 1.5 litre per minute through the flow gauge 38. The flow-stat 40 is set to provide the desired flow rate of 1 to 1.5 litre per minute and will maintain a substantially constant flow irrespective of any change of pressure of the water entering through the inlet 28. The flow gauge 38 has a window 39 having flow rate graduations 39a at which the rate of flow is indicated.

A flow switch 42 receives water from the flow-stat 40 and is sensitive to the rate of water flow. The switch 42 will remain open provided that the flow rate therethrough does not fall below a certain value, for example 0.8 litre per minute. However, should the flow rate fall below that value, the flow switch 42 will operate to shut off electricity supply

from the controller 34 to the solenoid valve 32 and to two pairs of electrolysers 44, 44a and to a peristaltic pump 50 described below. When switching on the apparatus from switch 25, switch 36 is pressed into an "on" position by-passing flow switch 42 and initiating water flow by operating the solenoid switch 32. The switch 36 is held in its "on" position long enough for a float in the switch 42 to lift from an open contact in the switch as water flows therethrough so that the switch 42 is then placed in a normal operating mode.

From the flow switch 42, water flows to an inlet 45 of a mixing chamber such as an T-junction 46 having a further inlet 48 which receives the saline solution entering through the coupling 30. As the water passes through the T-junction 46 from the inlet 45 towards an outlet 49 at its upper end, the saline solution mixes with the water thereby providing an electrolyte. Preferably, a mixture of 300 - 350 mg/l of brine per litre of water is drawn into the T-junction 46 to mix with the water.

From the T-junction 46, the mixture of water and electrolyte flow via a pressure switch 51, the operation of which is described below. From pressure switch 51, the mixture flows to a two-way valve 52 and then to junction 60, with supply outlets 62 of the junction 60 feeding mixture to junctions 63 and 63a for feeding the two respective pairs of electrolysers

44, 44a.

One of the electrolysers of the pair 44 is shown in diagrammatic cross section in Fig 2 and comprises a tubular outer electrode 66 (the cathode), a rod like inner electrode 68 (the anode) spaced from the electrode 66 and a tubular diaphragm 70 arranged between the electrodes 66, 68 so as to divide the space therebetween into a cathode chamber 72 and an anode chamber 74. The diaphragm 70 may be made of a ceramic based on, for example, zirconium oxide, and is an ultra- filtering type. The electrolyser shown in Fig 2 is of a known kind and is preferably of the type disclosed in US Patent No. 5635040. The anode chamber 74 has an inlet 80 and an outlet 82 and the cathode chamber has an inlet 76 fed from junction 63 and an outlet 78. The anode 68 and cathode 66 receive electric current as shown from the controller 34 via leads 33. The liquid flow paths of the two electrolysers of each pair are connected in parallel.

The liquid entering each cathode chamber 72 flows upwardly and leaves through the outlets 78, 78a. Junctions 83, 83a receive the liquid leaving the cathode chambers 72 as a catholyte and direct it to a four-way junction 84. The catholyte enters the junction 84 through substantially unrestricted inlets 85 and leaves through a restricted outlet 86 and a substantially unrestricted outlet 87. Catholyte passing through outlet 86

passes to an outlet 88 on the housing 10 via a flow adjuster 90. From the outlet 88, the catholyte can be collected in a suitable vessel. Catholyte passing through the outlet 87 passes to a Y junction 92 where the flow is split and directed to the inlets 80, 80a of junctions 79, 79a for the anode chambers 74 of electrolysers 44, 44a. The liquid flows upwardly through the anode chambers 74 and leaves as an anolyte through the outlets 82, 82a at the upper ends thereof. From there, the anolyte enters a further Y junction 94 which directs the anolyte to an outlet 96 on the housing 10 for collection in a suitable vessel 97.

There are four types of solution than can be produced by the apparatus described, ie three types of anolyte and a catholyte. The first is an alkaline anolyte of pH 7-8. The procedure for making an alkaline anolyte is to shut off pinch valve 90 so directing all the alkaline catholyte solution made in the cathode chambers 72 for re-processing in the anode chambers 74.

The second type of anolyte is a neutral anolyte of pH 6-7. To make a neutral anolyte the pinch valve 90 is opened slightly to allow a flow of catholyte to pass to outlet 88. The amount varies and should be adjusted to give a pH of 6-7. If the pH is above 7 the valve 90 is opened a little more and so the pH will drop. If the pH is below 6 the pinch valve 90

is open too far and should be closed a little.

The third type of anolyte is an acid anolyte pH varying between 2 and 6. For this type the valve 90 is opened fully to allow half the catholyte flow to pass to outlet 88 and half the flow to be directed into the anode chambers 72 of the electrolysers 44, 44a for activation and creation of the acidic anolyte. pH values for the various types of anolyte together with Redox readings are set out below.

The fourth type of solution produced is catholyte with a pH of 11 to 12 and a Redox Potential of -600 to -900. The catholyte solutions also have processing applications and are collected from outlet 88.

The four types of solution are set out in summary below:-

	pH	REDOX
Alkaline anolyte	7.5 - 9	+400 to +700 mV
Neutral anolyte	5.5 - 7.5	+600 to +900 mV
Acid anolyte	2 - 5.5	+900 to +1200 mV
Catholyte	11 - 12	-600 to -900 mV

The valve 90 may be operated automatically as described below.

Within the electrolysers 44, 44a, the saline mixture is subjected to a voltage of 16 or 32 volts in the example shown. A three position voltage selector switch 106 (eg 16 volt position, 32 volt position and a centre OFF position) is provided for that purpose. The electrolysers 44, 44a may use about 50 watts each of electricity i.e. a total of 200 watts per hour at a reading of 10 amps shown at an LCD display 98 on the housing 10. The solenoid valve 32 is activated by a voltage of around 24 volts DC or AC

The flow switch 42 operates and causes the controller 34 to shut off power to the electrolysers 44, 44a due to a fall in flow rate below a given rate, eg 0.8 l/min. An indication of that is provided by a lamp 110. This mode also cuts the power to the solenoid valve 32 to prevent water flow through the apparatus and the power to the peristaltic pump 50 is also shut down to prevent operation of the pump 50.

Due to calcium and magnesium carbonate being deposited as scale on the walls of the cathode chambers 72, flow rates therethrough will be reduced and periodic cleaning is required. Cleaning is recommended every 40 hours with the example shown and the number of operating hours is indicated at an LED indicator 111 on the housing 10. When flow rate falls due to a build up of scale an LED indicator 112 is

illuminated to show that cleaning is required. If a soft or calcium free water is used as the source at 29, cleaning may be carried out at less frequent intervals.

Cleaning is a very simple procedure. The pressure switch 51 will operate to prevent functioning of the apparatus when cleaning is imperative. To clean the apparatus the power is turned off with switch 25. The two-way valve 52 is turned to a cleaning position to allow cleaning solution to enter the apparatus through inlet 53 and prevent cleaning solution from entering the upstream water and saline flow paths. In that way cleaning solution is circulated only through the electrolysers 44, 44a and connecting pipe-work to normal outlets at 88 and 96. Cleaning solution is preferably 10% hydrochloric acid. Prior to introducing acid into the apparatus we prefer to drain out the liquid present in the electrolysers 44, 44a to prevent dilution and inactivation of the acid. Acid is then connected and fed into inlet 53 from a small external acid reservoir tank (not shown) and proceeds to the two-way valve 52 which directs it along normal downstream flow paths. From outlets 88 and 96 the acid can be piped back to the acid reservoir tank. Pinch valve 90 needs to be just partially open to ensure acid also circulates in the anode chambers of the electrolysers 44,44a. Acid is pumped until no gas bubbles are visible in the acid at outlets 88 and 96.

The two-way valve 52 is then turned back to its original position. It is then necessary to pass the acid in the unit to waste and flush out the electrolysers 44,44a with clean water. The power is then restored to the apparatus by operating switch 25. A control panel switch 118 is then moved from a processing to a flushing position. That opens the solenoid valve 32 to allow only water to flow through the apparatus and flush out the acid for several minutes. To recommence processing of the water the switch 118 is restored to its processing position. When switch 118 is in the flushing position, an LED light 119 will illuminate. Where the pressure switch 51 operates to switch off the apparatus a lamp 112 associated with the switch 51 will flash.

The salt used to make up a saline solution needs to be as pure as possible. Ideally a 99.9% pure salt is best and, by using such a salt, deposits in the electrolysers 44, 44a and connecting pipes will be greatly reduced.

The apparatus is not powered during the cleaning operation and cleaning is a totally separate operation. The acid acting on the carbonates will generate gas bubbles at outlet 88 and 96 and cleaning is complete when the air bubbles stop flowing from that outlet.

In certain cases, the presence of calcium or other natural minerals in the water will in itself provide sufficient electrolyte to enable a useful anolyte solution to be obtained. In such cases, a suction pipe 116 from the peristaltic pump 50 needs to be immersed in the water instead of a saline solution.

An LCD display 98 provides an indication of current flow through the electrolysers 44, 44a. Flow of current through the electrolysers will be dependent upon the amount of saline in the mixture delivered to the electrolysers. As mentioned above, the saline solution is delivered to the T-junction 46 by the peristaltic pump 50.

We prefer to insert a non-return valve 132 in the flow path between the flow adjuster 90 and the junction 79 to prevent the risk of reverse flow of liquid through the electrolysers 44, 44a.

The apparatus can be operated either manually or automatically. For manual operation, switch 25 is operated to provide mains electricity to the transformer 22. The switch 36 is then operated so that water and saline begin to flow through the apparatus. The flow switch 42, pressure switch 51 and sensors 100 and 104 will operate to control operation of the apparatus as described above when working in the manual mode of

operation.

Instead of operating manually, the system can operate automatically by providing an external Redox analyser 136 which receives 24 volts DC power from the controller 34 where indicated at 122. A pH analyser 138 is also connected to the controller 34. Both the Redox analyser 136 and the pH analyser 138 are set to sense desired Redox and pH values and are connected to probes (not shown) which sense the Redox value and the pH value of the solution being treated. Where the Redox level exceeds a preset level, a signal from the Redox analyser 136 will cause the controller 34 to switch off the apparatus downstream of switch 106 and to switch it on again when the Redox level falls below the present level. An LED 120 illuminates during that period. Where the pH value of the anolyte changes from a preset level, the pH analyser 138 will cause the controller 34 to alter the setting of flow adjuster 90 to change the pH value. An LED 139 illuminates when the pH probe is in use. A timer can be used instead of a Redox sensor and which is connected at 122 to the controller 34. The timer switches the apparatus on and off as required to maintain oxidant level in the treated solution.

Instead of using the flow gauge 38 and the flow stat 40, the two items can be replaced by a single flow control unit providing a fixed flow rate of fluid

therethrough.

Fig 3 shows a typical control sequence for the apparatus shown in Fig 1 and illustrates the way in which the system will be switched off in certain prevailing conditions and the operation of the various switches and sensors during the operation of the apparatus.

Power regulators (not shown) are provided to regulate the two voltages of 16 or 32 for the controller 34. To protect the power regulators cut-outs have been incorporated to operate at 16 Volts 15 amps and 32 Volts 11 amps. Should those current values be exceeded then the controller 34 will shut down power to the apparatus and an LED 124 will light up. To restore the power supply the controller 34 must be switched off at switch 25 and then switched on again.

A 24 Volt DC supply is also available from the controller 34 to supply power to an external water pump for supplying liquid to the apparatus when mains water pressure is not available.

The apparatus may be operated remotely with the switches 25, 36 and the various LED's and other indicators being arranged conveniently on a suitable remotely located console. The console can then be suitably connected electrically to the remainder of the apparatus.

The apparatus in accordance with the invention can be made particularly compact and portable for easy movement of the apparatus from one place to another.

The portable nature of the apparatus is useful when water purification is required at remote locations such as villages in third world countries where the apparatus can be used to purify a local water supply. In such a case, the electricity supply 24 can be provided by means of a portable generator and water can be pumped, say, from the river to the inlet coupling 28 on the housing 10.

CLAIMS

1. A method of electrochemical processing of liquid such as water comprising providing an electrolyser having cathode and anode chambers, the chambers including respective electrodes providing an electric current source for the electrodes of the electrode chambers, supplying to the electrolyser liquid to be subjected to the electrochemical processing and causing liquid from the cathode chamber to flow at least partly to the anode chamber, the remainder flowing along a further flow path.

2. A method of electrochemical processing of liquid according to claim 1 in which the pH of a solution being treated by the processed liquid is measured and the rate of electrolyte flow from cathode chamber to anode chamber is adjusted accordingly.

3. A method of electrochemical processing of liquid according to claim 1 or 2 in which the pH of the processed liquid is measured and the rate of electrolyte flow from cathode chamber to anode chamber.

4. A method of electrochemical processing of liquid according to claim 1, 2 or 3 in which the redox or oxidant value of a solution being treated by the processed liquid is measured and the processing of liquid is

stopped to maintain the value an started again when required.

5. A method of electrochemical processing of liquid according to any preceding claim in which the method further comprises the step of sensing when the electrochemical cell needs to be cleaned and cleaning the cell by flushing with a cleaning fluid.

6. A method of electrochemical processing of liquid according to claim 5 in which the cleaning method includes the further step of flushing the cell with clean water after cleaning with cleaning solution.

7. An apparatus for electrochemically processing liquid such as water comprising an electrolyser having cathode and anode chambers, means for providing an electric current source for the electrodes of the chambers, and means for causing liquid from the cathode chamber to flow at least partly to the anode chamber, the remainder flowing along a further flow path.

8. An apparatus for electrochemically processing liquid according to claim 7 in which the further flow path includes flow control means, such as a flow adjuster, for controlling flow along the further path.

9. An apparatus for electrochemically processing liquid according to claim 7 or 8 in which the aforesaid means for causing flow of liquid at least partly from the cathode chamber to the anode chamber and partly along the further flow path comprises a device having a substantially unrestricted inlet for the liquid from said cathode chamber and first and second outlets one of which may provide a greater resistance to flow therethrough than the other.

10. An apparatus for electrochemically processing liquid according to means is provided for sensing the pH value of a solution being treated by the processed liquid so that if the pH value changes from a predetermined value, control means such as the aforesaid flow control means is adjusted to control the rate of liquid flow along the further path which alters the flow rate of liquid from the cathode chamber to the anode chamber of the electrolyser.

11. An apparatus for electrochemically processing liquid according to claim 10 in which the means for sensing the pH value may also be used for determining the pH of the processed liquid and controlling the pH by using the aforesaid flow control means.

12. An apparatus for electrochemically processing liquid according

to any of claim 7 to 11 in which means is provided for sensing Redox value of the solution being treated by the processed liquid whereby if the Redox value varies from a predetermined value, the processing of the liquid is stopped to maintain the Redox value of the treated liquid and then started again when required.

13. An apparatus for electrochemically processing liquid according to any of claim 7 to 12 in which electrolyte is drawn from a supply by pump.

14. An apparatus for electrochemically processing liquid according to claim 13 in the pump is a peristaltic pump.

15. An apparatus for electrochemically processing liquid according to the electrolyte is fed to a mixing device such as a T-junction which receives the liquid to be processed so that the saline solution and liquid to be processed can be mixed together.

16. An apparatus for electrochemically processing liquid according to any o claims 7 to 15 in which, means is provided for indicating the need to clean the apparatus when resistance to flow increases as a result of the build up of lime scale.

17. An apparatus for electrochemically processing liquid according to any of claims 7 to 16 where a mixing device is provided for mixing liquid and electrolyte in which cleaning means is provided for introducing a cleaning solution into the apparatus so that the cleaning solution flows through a selected part of the apparatus preferably downstream of the mixing device.

18. An apparatus for electrochemically processing liquid according to claim 17 in which said cleaning means includes valve means for introducing cleaning solution from a suitable source.

19. An apparatus for electrochemically processing liquid according to any of claims 7 to 18 in which liquid which flows through the aforesaid further path is drawn along the path by a suitable suction device such as a vortex.

20. An apparatus for electrochemically processing liquid according to claim 19 in which a non-return valve is provided in the flow path for the liquid which flows partly to the anode chamber of the electrolyser to prevent the suction means from drawing liquid through the electrolyser in a reverse direction.

21. An apparatus for electrochemically processing liquid according to any of claims 7 to 20 in which two pairs of electrolysers are provided.

22. An apparatus for electrochemically processing liquid according to claim 21 in which the two pairs of electrolysers are connected so that the anode chambers are connected together in parallel and the cathode chambers are connected together in parallel.

23. An apparatus for electrochemically processing liquid according to any of claims 7 to 22 in which the apparatus is portable.

24. An apparatus for electrochemically processing liquid according to claim 23 in which the housing is provided with suitable inlets for the liquid and an electrolyte and suitable respective outlets for the required processed liquid and by-product from the electrolyser.

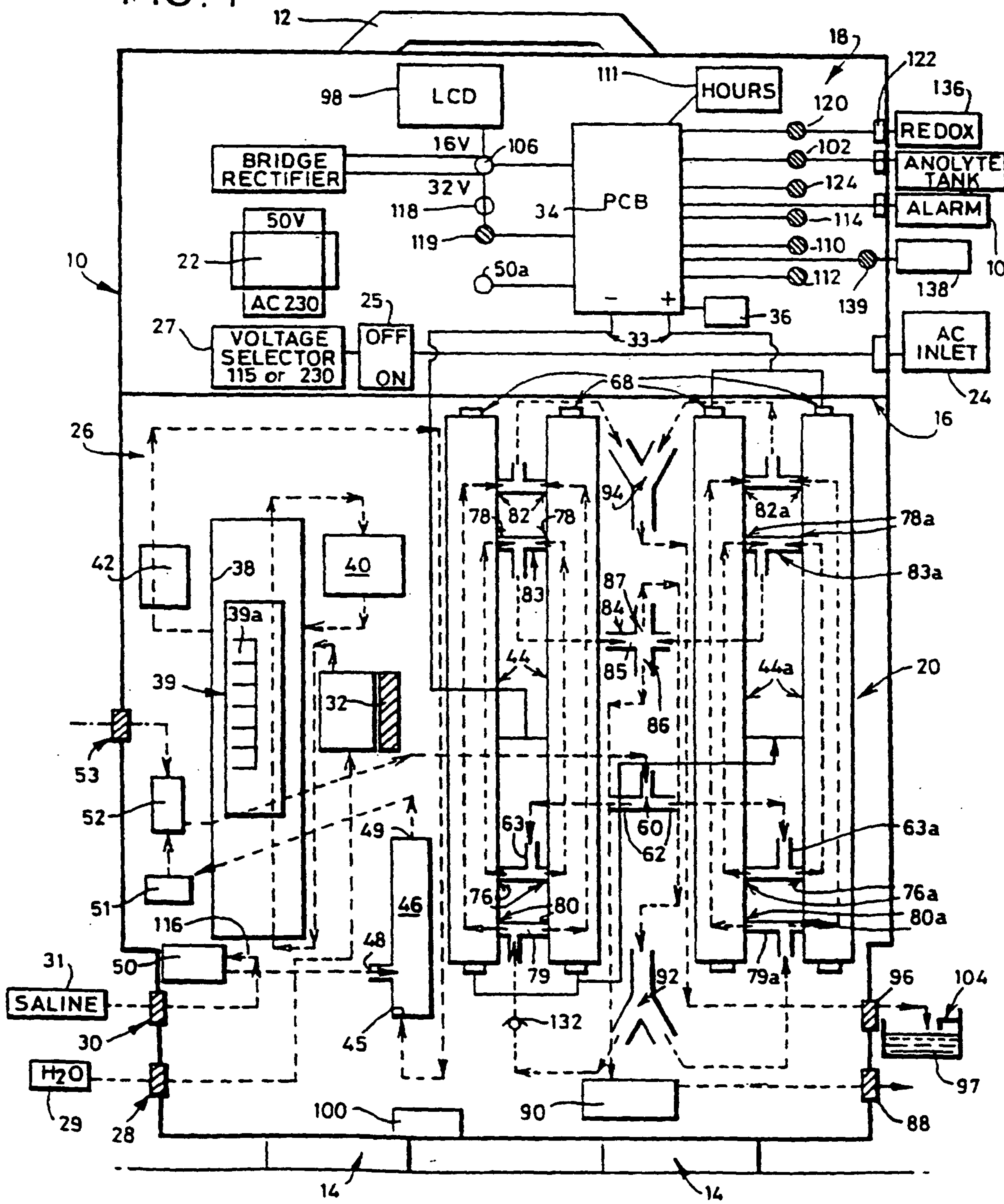
25. An anolyte solution produced by treating a brine/water mixture liquid according to the method of any of claims 1 to 6 or by the apparatus of any of claims 7 to 24 in which all of the liquid flows from the cathode chamber to the anode chamber and in which the solution is alkaline, having a pH in the range 7 to 9 and a redox value in the range +400 to +700mV.

26. An anolyte solution produced by treating a brine/water mixture liquid according to the method of any of claims 1 to 6 or by apparatus of any of the claims 7 to 24 in which a large proportion of the liquid flows from cathode chamber to anode chamber and a small proportion flows along a further flow path, the separate liquid flows combining to form a solution of substantially neutral pH, in the range 5.5 to 7.5 and a redox value in the range +600 to +900mV.

27. An anolyte solution produced by treating a brine/water mixture liquid according to the method of any of claims 1 to 6 or by apparatus of any of the claims 7 to 24 in which half of the liquid flows from the cathode chamber to the anode chamber and half flows along the further flow pattern, the separate liquid flows combining to form a solution of acid pH in the range 2 to 6 and a redox value in the range +900mV to +1200mV.

28. A catholyte solution produced by treating a brine/water mixture liquid with the apparatus according to any of claims 7 to 24 in which the means for causing liquid to flow at least partly to the anode chamber is disabled so as to produce a catholyte solution having a pH in the range 11 to 12 and a redox value in the range -600 to -900 mV.

FIG. 1


LCD
HOURS
BRIDGE RECTIFIER
PCB
50V
AC 230
VOLTAGE SELECTOR 115 or 230
OFF
ON
REDOX
ANOLYTE TANK
ALARM
AC INLET
SALINE
H2O
16V
32V

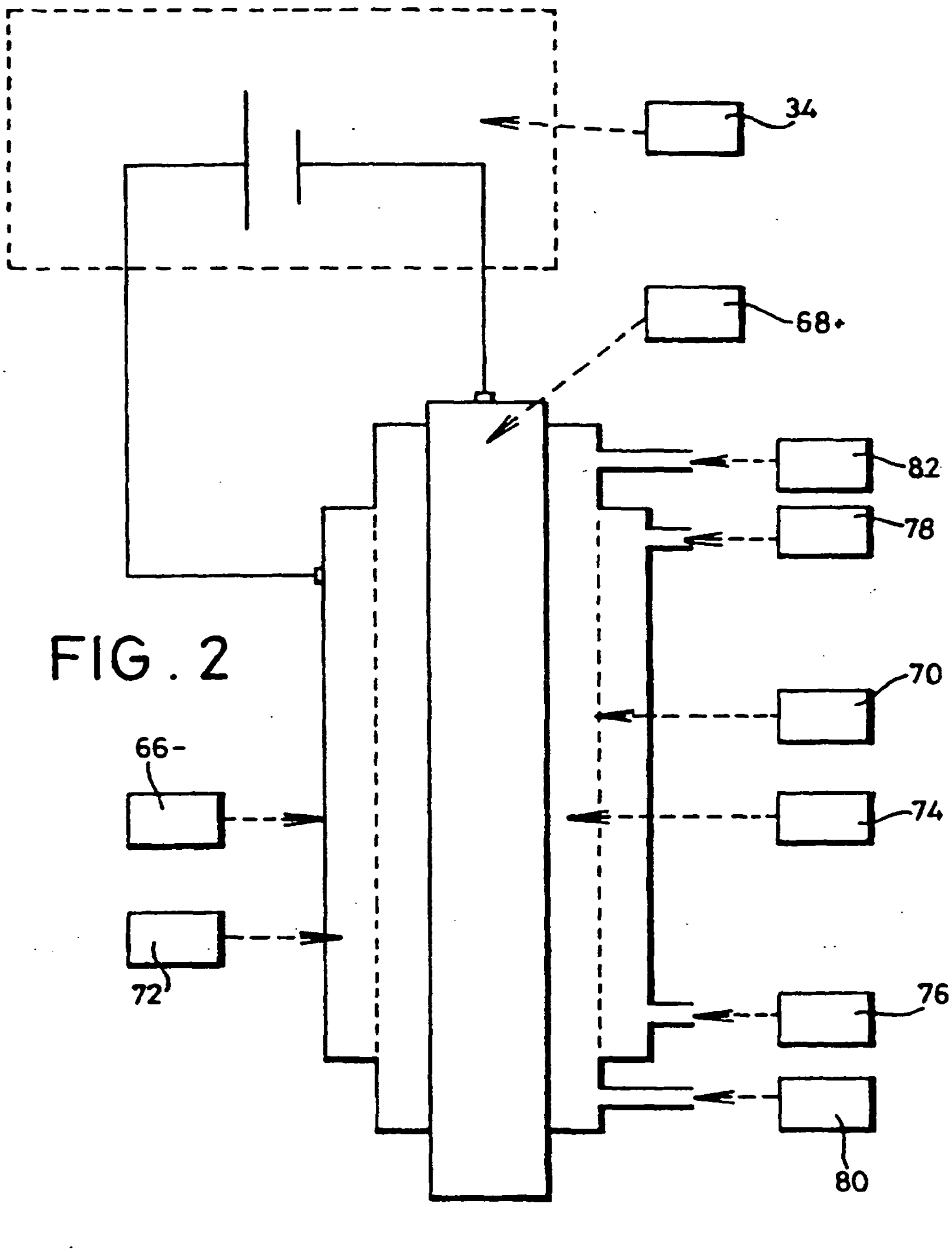


FIG. 2

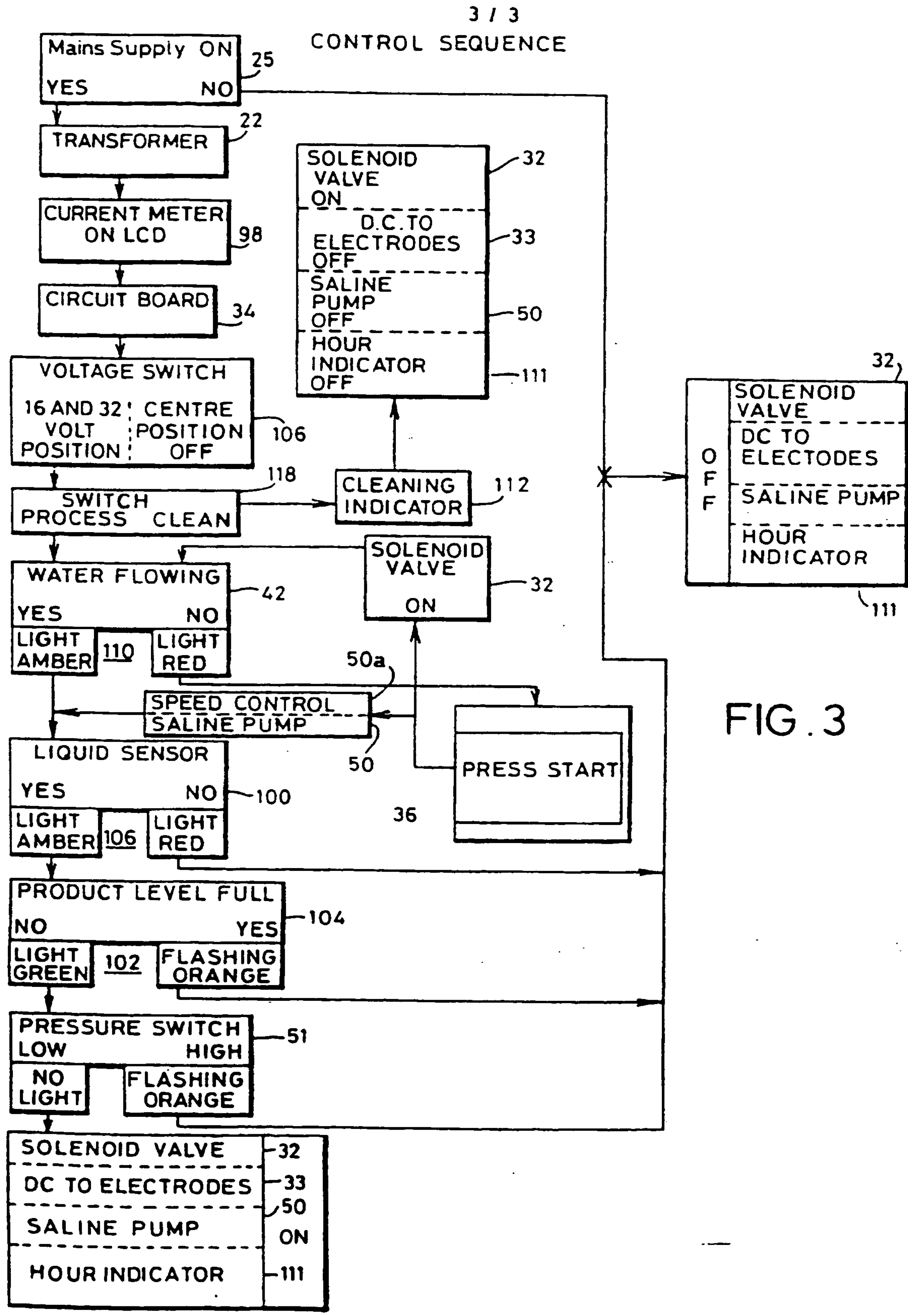

CONTROL SEQUENCE
Mains Supply ON
YES
NO
25
TRANSFORMER
22
CURRENT METER ON LCD
98
CIRCUIT BOARD
34
VOLTAGE SWITCH
16 AND 32 VOLT POSITION
CENTRE POSITION OFF
106
SWITCH
PROCESS
CLEAN
118
CLEANING INDICATOR
112
SOLENOID VALVE ON
32
D.C. TO ELECTRODES OFF
33
SALINE PUMP OFF
50
HOUR INDICATOR OFF
111
WATER FLOWING
YES
NO
42
LIGHT AMBER
110
LIGHT RED
SOLENOID VALVE ON
32
50a
SPEED CONTROL
SALINE PUMP
50
PRESS START
36
LIQUID SENSOR
YES
NO
100
LIGHT AMBER
106
LIGHT RED
PRODUCT LEVEL FULL
NO
YES
104
LIGHT GREEN
102
FLASHING ORANGE
PRESSURE SWITCH
LOW
HIGH
51
NO LIGHT
FLASHING ORANGE
SOLENOID VALVE
32
DC TO ELECTRODES
33
SALINE PUMP
50
ON
HOUR INDICATOR
111
OFF
SOLENOID VALVE
32
DC TO ELECTODES
33
SALINE PUMP
50
HOUR INDICATOR
111

FIG. 3

INTERNATIONAL SEARCH REPORT

Int tional Application No
PCT/GB 97/02666

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C02F1/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C02F C25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 5 628 888 A (BAKHIR ET AL) 13 May 1997	1,7,13, 15,26,28
P,A	see the whole document	8,20-22, 25,27
A	US 5 427 667 A (BAKHIR ET AL) 27 June 1995 see figure 7; examples	1,7, 25-28
A	US 4 904 357 A (SHARIFIAN ET AL) see figure 2	1,7
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-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 January 1998	29/01/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ruppert, G

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INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/GB 97/02666

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Inter· ·nal Application No
PCT/GB 97/02666

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